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# Omental Free-tissue Transfer for Coverage of Complex Upper Extremity and Hand Defects—The Forgotten Flap

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**Abstract** Free omental tissue transfer is a versatile reconstructive option for trunk, head and neck, and extremity reconstruction. Its utility is due to the length and caliber of the vascular pedicle and the malleability and surface area of the flap. We report our experience with omental free flap coverage of complex upper-extremity defects. A retrospective analysis of eight omental free-tissue transfers in seven patients with complex upper-extremity defects between 1999 and 2008 was performed. Indications, operative technique, and outcome were evaluated. Patient age ranged from 12 to 59 years with five male and two female patients. Indications included tissue defects due to crush-degloving injuries, pitbull mauling, or necrotizing soft tissue infection. All patients had prior operations including: revascularization, debridement, tendon repair, skin grafts, and/or fixation of associated fractures. One patient sustained severe bilateral crush-degloving injuries requiring free omental hemiflap coverage of both hands. The mean defect size was 291 cm$^2$ with all patients achieving complete wound coverage. No flap loss or major complications were noted. Laparoscopic-assisted omental free flap harvest was performed in conjunction with the general surgery team in three cases. Mean follow-up was 2 years. The omental free flap is a valuable, often overlooked reconstructive option. The long vascular pedicle and large amount of pliable, well-vascularized tissue allow the flap to be aggressively contoured to meet the needs of complex three-dimensional defects. In addition, laparoscopic-assisted harvest may aid with flap dissection and may result in reduced donor-site morbidity.

**Keywords** Omentum · Free flap · Upper-extremity defect · Upper extremity reconstruction

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## Introduction

The omental flap is one of the oldest most versatile options in reconstructive surgery. Its versatility is related to the large amount of pliable tissue, the long and reliable vascular pedicle, the associated lymphoid tissue (milky spots) [26], and the angiogenic factors which stimulate neovascularization [27, 30]. Historically, the importance of the omentum in preventing peritonitis due to intraabdominal adhesion formation was recognized in 1829 by a military surgeon, Antoine Joseph Jobert de Lamballe. As reconstructive surgery evolved, the first extraperitoneal use of the omentum as a pedicle flap for an arthroplasty was performed in 1926 by a German surgeon, V. Knazozovichy [13]. In 1936, the British heart surgeon, Laurence O'Shaugnessy utilized a pedicled omental flap for reperfusion of ischemic myocardium in an experimental animal model [18]. In 1948, John E. Cannaday described a lengthening technique for the omentum [3]. Subsequently, the omentum was used for reconstruction of the trunk, head and neck, and extremities [5, 8].

With the evolution of microvascular surgery, McLean and Buncke performed the first successful free-tissue transfer using the omentum for scalp reconstruction [16]. The reported advantages of the omentum included its vessel size, low metabolic demand, and angiogenic and immunologic capacity [16]. Since then, omental free-tissue transfer has become a reliable reconstructive option with acceptable donor–site morbidity [10].

*Anatomy and Embryology* The omentum develops in the 7th to 8th week of gestation [12]. In the 26th gestational week, the lymphoreticular tissue (milky spots) appear. This tissue peaks in number at age 1, and then decreases with aging. The omentum has four layers of peritoneum folded on each other, hangs from the greater curvature of the stomach, and drapes the transverse colon. The omentum is supplied by the right and left gastroepiploic arteries and veins, with an arterial diameter ranging from 1.5 to 3.6 mm [17]. The omentum contains a trabecular connective tissue framework with arteries, veins, lymphatics, fat pads, mesothelial cells, and lymphoreticular bodies [27]. Interestingly, even after flap transfer, the omentum releases polypeptide growth factor and activated macrophages, which results in capillary ingrowth into surrounding tissue [12]. Because of the omentum's antimicrobial defense mechanisms, ability to stimulate neovascularization [2], and lymphatic and angiogenic capacities, the omentum is a particularly useful flap in situations of severe upper extremity trauma with soft tissue loss.

## Materials and Methods

A retrospective analysis of eight omental free-tissue transfers in seven patients with complex upper-extremity defects between 1999 and 2008 was performed. Indications, operative technique, and outcome were evaluated. The mean defect size and mean time for follow-up were calculated.

### Surgical Technique

Recipient vessels are identified prior to omental flap harvest. Following recipient vessel identification, the general surgery team begins with laparoscopic exploration of the omentum. Omental dissection commences with its detachment from the transverse colon. The left and right gastroepiploic vessels are then identified and dissected in a retrograde fashion to their origin from the splenic and the gastroduodenal arteries, respectively. A template of the defect helps to define the size of the omental flap. In most cases, the right gastroepiploic artery is preferable in caliber. Next, the short gastric vessels are divided from the greater curve of the stomach. After isolation of the right gastroepiploic artery and distal division of the left gastroepiploic artery, a small upper-midline incision is made. At this point, the omentum is transferred extra-abdominally. Additional pedicle length can be achieved by division of the gastroepiploic and middle omental vessels [1, 6, 24]. This was performed once in our series (Fig. 1). Finally, the right gastroepiploic vessels are divided and the microvascular anastamoses are performed. In case 5, a bilateral hand reconstruction necessitated a bilateral omental hemiflap. Our technique was similar to that described by Weinzweig et al. [29]. The omentum was harvested, the right gastroepiploic arterial and venous anastamoses were performed, and the entire omental flap was allowed to perfuse. At this point, the intra-omental vascular anatomy was assessed, and the omental hemiflaps were designed based upon the omental perfusion pattern [29] (see Fig. 2).

## Case Series/Results

Patient age ranged from 12 to 59 years with five male and two female patients. Indications included tissue defects due to severe trauma or infection (see Table 1).

*Case 1* Patient 1 was a 27-year-old male who sustained a crush injury resulting in near complete amputation of both hands. This required revascularization, ORIF of associated fractures, soft tissue debridements, and an omental free flap with split-thickness skin graft (STSG) to the right hand. The defect size was 140 $cm^2$. The patient required additional surgery secondary to osteomyelitis 4 months after the initial injury. Additionally, a subsequent debulking procedure was performed 9 months later. The patient is doing well at 9.5 years follow-up and works as a massage therapist.

*Case 2* Patient 2 was a 38-year-old male with massive tissue loss of the forearm and arm due to necrotizing fasciitis and compartment syndrome. Multiple debridements were performed, resulting in a large dead space, denuded flexor tendons, exposed radius and median nerve, and a defect measuring 540 cm$^2$. An omental free flap and a STSG were performed. The patient had a minor abdominal wound infection that healed with local care. He has regained partial hand function at 9 months follow-up (Fig. 1).

*Case 3* Patient 3 was a 21-year-old male with a crush-degloving injury of the left dorsal hand. Initial treatment involved local care followed by a skin graft. One year later, he required additional surgery for extensor tendon realignment and release of webspace contractures. The 150 cm$^2$ defect over the extensor tendons was reconstructed with an omental free flap and STSG. The patient had minor skin graft loss over the omental flap which healed by secondary intention. At 8 months follow-up, he was healed and undergoing therapy.

*Case 4* Patient 4 was a 13-year-old male who had severe four extremity injuries after a pitbull mauling. Multiple prior procedures included: skin grafts, tissue expansion, and scapular free flap to reconstruct a circumferential defect of his right forearm. Due to the persistent circumferential right forearm deformity measuring 750 cm$^2$, an omental free flap with STSG was performed. An interpositional saphenous vein graft was required for arterial inflow. The patient healed without complications and has improved contour with stable function of his right forearm at 8 months follow-up (Figs. 3, 4, and 5).

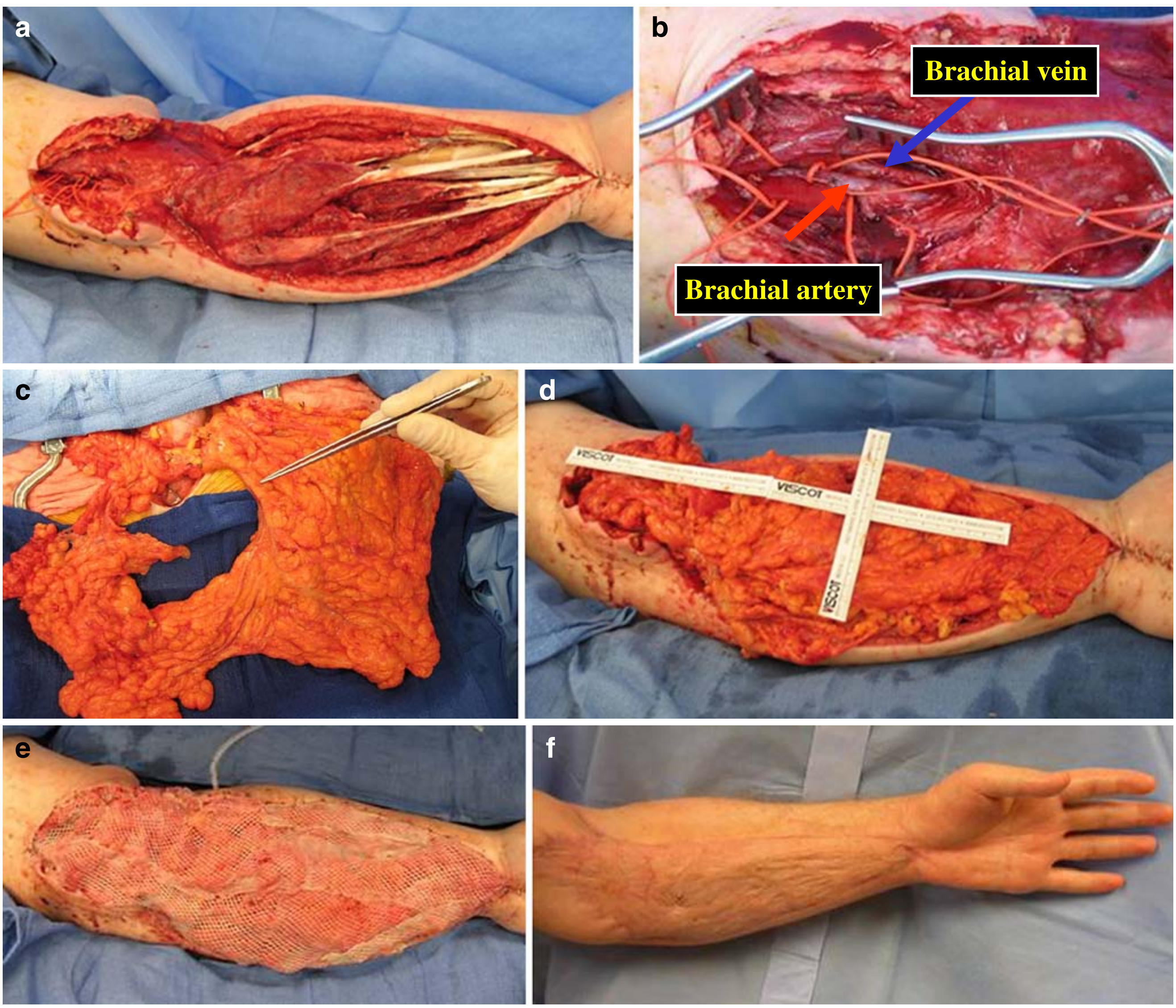


**Figure 1** Case 2, patient with necrotizing soft tissue infection requiring fasciotomy and debridement. **a** After debridement, **b** exposure of recipient vessels, **c** harvest and lengthening of omental flap, **d** insetting of omental flap, **e** coverage with meshed STSG, **f** at 9 months follow-up.

**Figure 2** Case 5, patient with bilateral hand crush/degloving injury, **a**, **b** defect after debridement and exposure of recipient vessels; **c**, **d** omental flap harvest and design of hemiflap templates; **e**, **f** insetting of omental hemiflap and coverage with STSG.

*Case 5* Patient 5 was a 59-year-old female who sustained bilateral dorsal hand degloving injuries secondary to a motor-vehicle collision. Associated injuries included multiple metacarpal and phalangeal fractures as well as multiple tendon injuries. Tendon repair and ORIF of fractures was performed and negative pressure wound therapy was utilized until the patient's overall medical condition stabilized. The tissue defect measured 176 cm$^2$ on the left hand and 126 cm$^2$ on the right hand. Her history included a previous hysterectomy and ectopic pregnancy performed through a midline abdominal incision extending 1.5 cm above the umbilicus. Because of her history of previous abdominal surgery, a preoperative CT-angiogram of the abdomen was performed in order to assess the

**Table 1** Patient table with initial injuries and treatments prior to omental free-tissue transfer.

| Patient | Age/ gender | Indication/initial injury | Previous treatments |
|---|---|---|---|
| 1 | 27 M | Severe bilateral crush injury-bilateral near complete amputation of hands at carpal–metacarpal level, multiple bony, soft tissue, and vascular injuries | Wound debridement, ORIF of fractures, salvage revascularization with vein graft left hand, repair of multiple lacerations and 4x6cm STSG to left palm. |
| 2 | 38 M | Necrotizing fasciitis and compartment syndrome left forearm and arm | Multiple debridements of infected and devitalized tissue |
| 3 | 20 M | Degloving injury left dorsal hand | Skin graft |
| 4 | 13 M | Four extremity defect due to pitbull mauling | Multiple debridements, STSG, FTSG, tissue expansion, scapula free flap |
| 5 | 52 F | MVC, multiple crush injuries bilateral hands, multiple metacarpal and phalangeal fractures, extensor tendon injuries | Multiple debridements, ORIF of fractures and repair of tendons, negative pressure wound therapy |
| 6 | 54 M | Crush-degloving/burn injury right forearm secondary to conveyor belt, distal ulnar fracture | Multiple debridements, external fixation, negative pressure wound therapy |
| 7 | 12 F | MVC, right hand extensor surface degloving injury | Debridements, tendon grafting |

omental vascular anatomy. The right gastroepiploic vessels were identified, but no left gastroepiploic vessels were seen. These findings were confirmed intraoperatively. The entire omental flap was first anastamosed to the left hand. The right gastroepiploic artery was anastamosed end to side to left radial artery, and the right gastroepiploic vein was anastamosed end to end to left cephalic vein. After examination of the intra-omental perfusion pattern, the flap was divided. The right omental artery was then anastamosed end to side to the right radial, and the right omental vein was anastamosed end to end to a dorsal vein on the right dorsal hand. Non-fenestrated skin grafts were used for coverage of the omentum (Fig. 2). The patient required partial flap debridement and revision skin grafting of the left-sided flap 7 weeks after the initial procedure. She healed uneventfully.

*Case 6* Patient 6 was a 54-year-old male who sustained a combination of crush-degloving and thermal injury of the right forearm related to an industrial conveyor belt. This resulted in circumferential tissue loss of the right forearm, as well as a distal ulnar fracture. Initial management consisted of fasciotomies, external fixation, and serial debridement with negative pressure wound therapy. After the wound bed stabilized, an omental free flap and STSG measuring 400 cm$^2$ were performed. He had an uneventful post-operative course and is undergoing therapy at 6 months follow-up (Fig. 6).

*Case 7* Patient 7 was a 12-year-old female involved in a motor-vehicle collision resulting in a degloving injury of the entire dorsum of her right hand. She underwent multiple debridements and tendon grafting prior to omental free flap coverage of a 48 cm$^2$ defect. The patient healed without complication and was lost to follow-up after 6 months.

All patients had several prior operations including: revascularization, wound debridement, skin grafts, and fixation of associated fractures. The mean defect size was 291 cm$^2$ with all patients achieving complete wound coverage with omental free flap and split-thickness skin

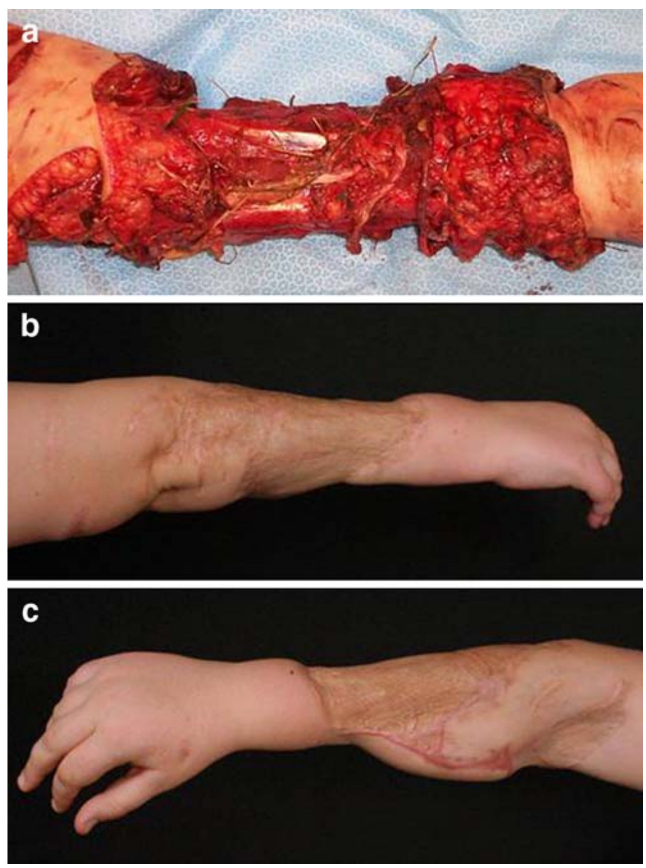


**Figure 3** Case 4, **a** preoperative image of right arm after pitbull mauling, **b**, **c** after initial wound coverage with STSG and scapular free flap at 1 year follow-up.

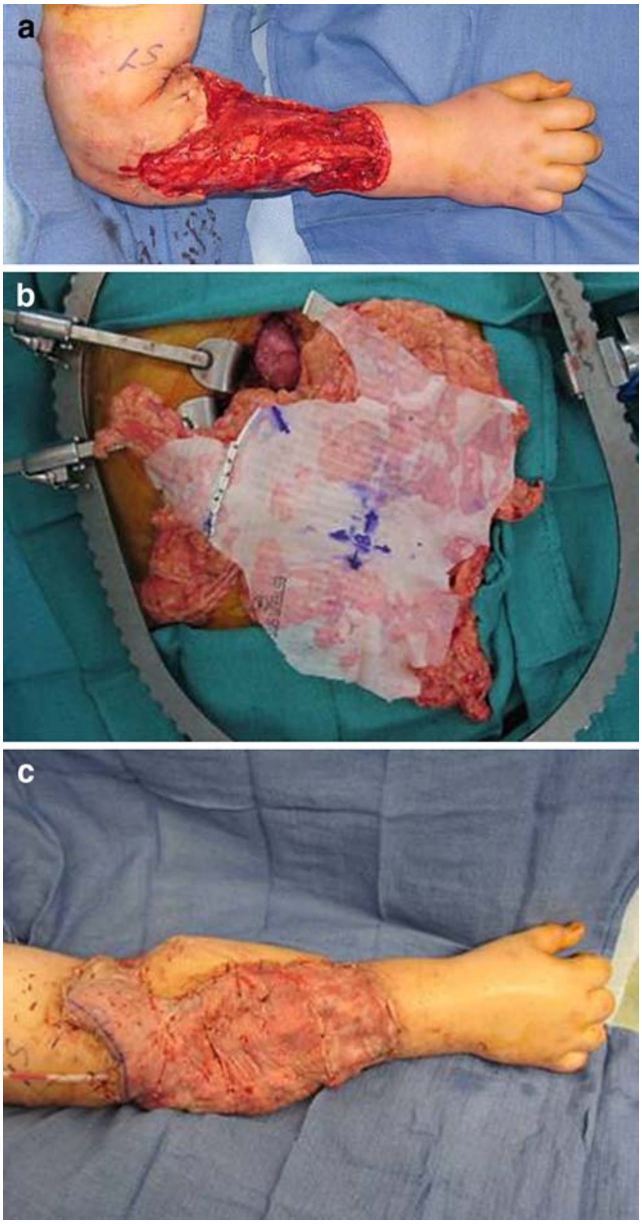

**Figure 4** Case 4, **a** after excision of STSG, **b** harvest and design of omental free flap, **c** insetting and coverage with STSG.

graft. Partial flap loss necessitating debridement and repeat skin grafting was performed in one patient. Laparoscopic-assisted omental free flap harvest was performed in three cases in conjunction with the general surgery team. Mean follow-up was 2 years (see Table 2).

## Discussion

There are many options for upper extremity reconstruction. Flap choice depends upon multiple factors such as defect size, location, etiology, and exposure of vital structures. Other factors such as the patient's general medical condition and past surgical history may play a role as well. We believe that the omental flap is specifically useful for extremity salvage when considerable tissue loss as a result of trauma or infection has occurred.

The omentum has been used since the nineteenth century. Early reports describe its use as a free graft, without a microsurgical anastomosis [28]. Although, the omental flap was initially transferred as a pedicle flap, it was also the first successful free flap described in the literature by McLean and Buncke [16]. Indications for omental free flap coverage include contour deformities, dead-space obliteration, coverage of vascular grafts or alloplastic materials, and simultaneous resurfacing and revascularization with flow-through flaps [19]. Unique advantages of the omental flap over fasciocutaneous or muscle flaps include (1) the length and caliber of the vascular pedicle [1, 6, 24] which may permit vascular repairs outside the zone of injury without the use of vein grafts, (2) the pliability of the tissue which may facilitate the reconstruction of complex three-dimensional defects, (3) the ability to aggressively contour and/or tailor the flap due to its reliable vascular anatomy, and (4) the long ischemia time due to its low metabolic demand. These qualities make the omentum a robust flap and help to minimize the chance of flap loss. In addition, the omentum's rich lymphatic system helps to absorb edema, thereby decreasing swelling in traumatized areas.

The omentum has a unique set of mesenchymal immune cells called “milky spots” which form the omental-associated lymphoreticular tissue. These cells generate specialized immune cells which may facilitate healing and

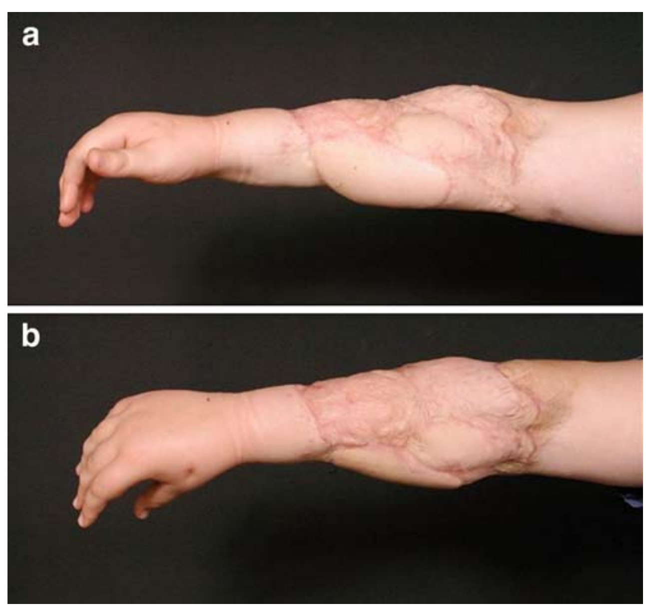

**Figure 5** Case 4, **a**, **b** patient at 7 month follow-up.


**Figure 6** Case 6, **a**, **b** patient after wound debridement and external fixation of distal ulnar fracture, **c**, **d** insetting of omental free flap and coverage with STSG, **e**, **f** at 5 month follow-up.

help fight infection. In a rat model, Singh et al. demonstrated that omental stromal cells can be cultured from activated omentum. These cells produce high levels of vascular endothelial growth factor and exhibit stem cell properties enabling them to be used for repair and possibly regeneration of damaged tissues [27]. Furthermore, the rich omental blood supply in association with its immunologic properties may make the omentum helpful in the treatment of irradiated wounds [20, 25]. However, the ability to stimulate neovascularization has extended the role of the omentum beyond wound coverage. The unique physiology of the omentum has led to its use in a variety of central-nervous-system disorders such as spinal cord injury, stroke, cerebral palsy, Alzheimer's disease, Parkinson's disease, and MoyaMoya [9, 11].

Our experience with omental tissue transfer in complex upper-extremity deformities with exposed vital structures has led us to believe that coverage with this well-vascularized, pliable tissue offers an advantage over negative pressure wound therapy followed by skin grafting. The ability to achieve stable wound coverage with a gliding surface is helpful for tendon function. Besides that, the intra-omental vascular anatomy allows for small omental segments to be reliably transferred. This was especially important in our fifth patient, in which bilateral hemiflaps were performed. Furthermore, if secondary tendon surgery is required, the omentum can be elevated facilely. Alternatively, secondary procedures may be performed through access incisions placed directly within the substance of the flap. This may be related to the well-developed intra-

**Table 2** Patient table with operative details, defect size, follow-up and outcome.

| Patient | Procedure/defect size | Omental flap harvest | Anastomosis | Follow-up | Outcome |
|---|---|---|---|---|---|
| 1 | Debridment and omental free flap, STSG 140 $cm^2$ to right hand | Laparoscopic-assisted | R. gastroepiploic A. to radial A. end to side, R. gastroepiploic V. end to side to cephalic V. | 9.5 years | Re-operation due to osteomyelitis 4 months later, debulking procedure 9 months later, Works as massage therapist |
| 2 | Debridments and omental free flap, STSG 540 $cm^2$ to left upper extremity | Laparoscopic-assisted | R gastroepiploic A. to brachial A. end to side | 8 months | Abdominal donor site wound infection-healed with local wound care |
| | | | R. gastroepiploic V. to brachial V. end to side | | Upper extremity regaining function |
| 3 | Excision of hypertrophic scar, release of webspace contractures extensor tendon realignment, omental free flap, STSG, 150 $cm^2$ to left hand | Laparoscopic-assisted | R. gastroepiploic A. to radial snuff box end to side<br>R. gastroepiploic V. to cephalic V. | 8 months | Minor skin graft loss-healed by secondary intention |
| 4 | Scar excision, tenolysis and omental free flap with STSG, 750 $cm^2$ to right forearm | Laparotomy | R. gastroepiploic A. to brachial A. end to side, with saphanous V. interposition, R. gastroepiploic V. to brachial V. | 7 months | Defect covered, no complications |
| 5 | Debridment and bilateral free omental hemiflap Left 9.5×18.5 cm (176 $cm^2$), Right 9×14 cm (126 $cm^2$) covered with STSG | Laparotomy | Left: R. gastroepiploic A. end to side to left radial A., R. gastroepiploic V. end to end to left cephalic V.<br>Right: R. omental A. end to side to the radial A. in the snuff box and R. omental A. end to end to a dorsal vein on the right dorsal hand | 6 months | debridement and revision skin grafting of the left hand seven weeks post operatively |
| 6 | Debridment and omental free flap with STSG 400 $cm^2$ to right forearm | Laparotomy | R. gastroepiploic A. and V. to radial A. and antecubital V. end to end | 5 months | Defect covered, regaining function |
| 7 | Debridment and omental free flap with STSG 48 $cm^2$ to right hand | Laparotomy | R gastroepiploic A. to radial snuff box end to side<br>R. gastroepiploic V. to cephalic V. end to end | 6 months | Defect covered adequate tendon function |

*R.* right, *L* left, *A* artery, *V* vein, *STSG* split-thickness skin graft

omental vascular network and/or vascular ingrowth from surrounding tissue. In our series, Patient 3 underwent additional tendon releases 10 months after the initial flap. There was no difficulty in elevating the flap, nor was there vascular compromise of the flap.

In spite of the potential advantages of the omentum, the use of omental free flaps is somewhat limited due to the potential morbidity associated with a laparotomy. Potential contra-indications could include previous upper abdominal surgery or co-morbid conditions precluding a laparotomy or laparoscopic harvest. In the event of previous abdominal surgery, CT-angiography may be helpful in evaluating the vascular pedicle.

However, routine CT scans are not performed. In our case series, we had one abdominal donor-site wound infection which healed by secondary intention. No other significant donor-site complications occurred. The ability to harvest the omentum laparoscopically may decrease the morbidity of this operation [4, 7, 21–23]. However, even with a standard laparotomy, the donor-site complication rates are low, reportedly 5.6% [10].

## Conclusion

We describe a case series of patients undergoing complex upper extremity reconstruction with free omental transfer. In comparison with other frequently used reconstructive options, the omental free flap offers a long vascular pedicle and a large amount of pliable, well-vascularized tissue. This allows the flap to be contoured for complex three-dimensional defects. In addition, laparoscopic-assisted harvest may aid with flap dissection and may result in reduced donor-site morbidity.

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